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The design and optimization of Central Core Dam Based on CATIA

Wenting Zhan*

PowerChina Guiyang Engineering Corporation Limited, Guiyang 550081, Guizhou, China.

*Corresponding author e-mail: 576157884@qq.com

Abstract. Based on the CATIA software, a parameterized model on central core dam is developed, which associated with a design table and can be controlled and updated by data in the Excel Sheet. A second developing program is developed by Visual Basic accordingly, achieving the output of engineering quantity on one-click. The research offers an easy way to carry out central core dam design, scheme comparison and optimization. It's can be applied on other similar projects with easy operation, less human error, and more efficiency. Furthermore, This solution has great promotional value since it provides a reference on CATIA application for more complex parameterized structures.

1. Introduction

Central core dam is a representative local material dam, because rigorous conditions concerning climate, topography, and geology are relaxed [1]. The traditional design method for central core dam is rely on two-dimension AutoCAD and similar softwares, which is difficult to optimize in time. The CATIA 3D design software developed by Dassault Systemes has the advantages of high visualization, good updateability and easy optimization of program selection. It has been widely used in the field of 3D design of hydraulic structures such as gravity dam [2], arch dam [3], face rockfill dam [4], central core dam [5] [6], flood discharge system, plant, slope [7], construction layout, etc. Compared with the traditional two-dimensional design method, The outstanding merits of CATIA adapted in hydraulic structures are mainly: (1) the 3D model can be updated by the parameters; (2) it is easy to get the concerning data, such as the embankment volume, excavation volume, reinforced area et.

At present, to establish a central core model in CATIA, a few days would be involved for an engineer who can handle CATIA software. And more time would be engaged because of the change of design scheme, which is very common in the in early design stage. Taking the central core dam as an example, a lot of sketches and constrains should be created in consideration of the complex zoning inside the dam and the excavation face design related to the topographical geological conditions. What's more, it's not easy for others to reuse the model, it takes time to understand the process and ideas of the initial modeling as well as modification of many parameters, and even the geometric relationship of the model is wrong, and the update fails. In terms of statistical engineering quantity, each volume and area is measured one by one. If the model modifies a lot, the measurement work will be done again and again.

This paper provides a design idea of building a three-dimensional model of a central core dam in a skeleton-driven manner, correlating model parameters with an Excel sheet, and supporting the development of a central core dam engineering quantity statistical tool to achieve a one-click statistical engineering quantity. It saves initial modeling time for designers, and saves a lot of human operation. The model along with the second development software can be reused for implementing proposal comparison and the quanlity calculation, which make it possible for any other central core dam project.

2. Parametric Design of central core dam

Establishing a reasonable, updatable 3D model is a key prerequisite. In this paper, the design of the central core dam adopt follows the “top to down” concept. Firstly, the dam axis and the coordinate origin are determined. Based on this, the model skeleton with points, lines and faces as elements is established. Based on the skeleton, combined with the terrainand geological conditions, then creat the central cores, excavation and other structural divisions one by one. All design processes are origined from the skeleton. This strict logical hierarchy ensures the effectiveness of the skeleton driving and model updating. As is shown in Fig. 1.

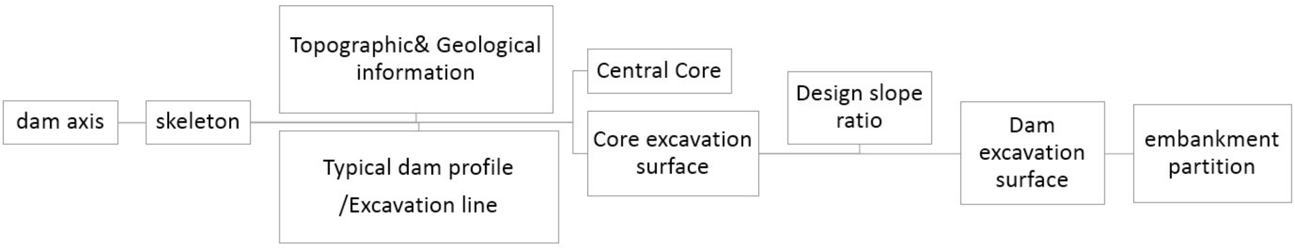

Fig. 1 Steps of modeling a core dam

2.1. Define the coordinate system and skeleton system

Based on the dam axis and the coordinate origin, the model skeleton with points, lines and faces as elements is established one by one, such as the dam crest plane, cross section, longitudinal section, etc.

2.2. Create a topographic geological model

First, enter the Digital Shape Editor module In CATIA, then use the Import command to import point data from the terrain or geological surface, and use the Mesh Creation command to triangulate the point cloud. Then enter the Quick Surface Reconstruction module and use the Automatic Surface command to fit the triangulated mesh to the terrain surface and the geological stratification.

2.3. Draw a typical cross sketch of the dam

Create a typical cross-section sketch of the central core dam on its plane, including the central core and each rockfill partition. Each partition is defined as a sketch, and each structural dimension is constrained by design parameters.

2.4. Drawing the central core excavation sketch

The foundation can be visually determined in a three-dimensional environment and dynamically adjusted beyond the topographic and geological information, benefit by the advantages of CATIA. The specific operation method is as follows: (1) set the geological terrain surface to a certain transparency; (2) enter the sketch editor;(3) determine the foundation of the central core in combination with the actual topography and geological conditions.

2.5. Create a central core

Stretch the central core sketch along the axis of the dam, and the excavation profile is stretched and divided along the river direction to obtain the central core, as shown in Fig. 2.

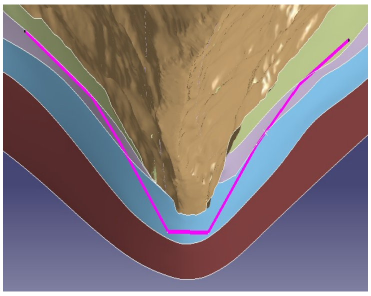

Fig. 2 Modeling of central core

2.6. Dam excavation surface creation

The excavation face of the central core dam includes the excavation of the central core below the dam crest and the excavation of the abutment above the dam crest. After the foundation of the central core is determined, the upstream and downstream boundaries can be extracted, and being stretched upwards and downwards according to the design slope ratio. Combine the foundation surface of the central core and the terrain, a junction excavation area is formed. As is shown in Figure 3.

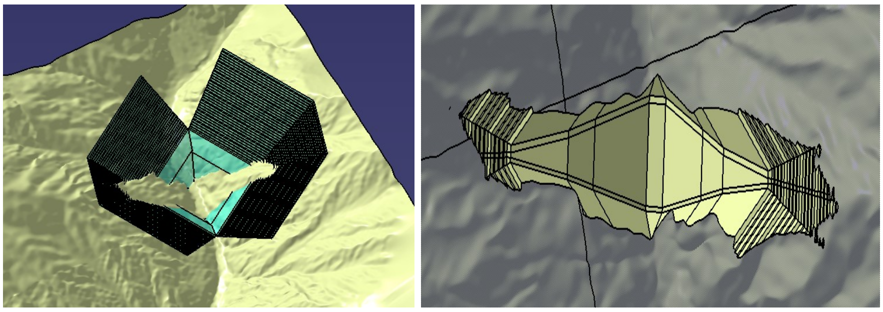

Fig. 3 Modeling of dam excavation surface

2.7. Dam shell partition

Stretch the partition sketch along the dam axis, then divide them by the excavation face, in this way, the rockfill partitions are obtained.

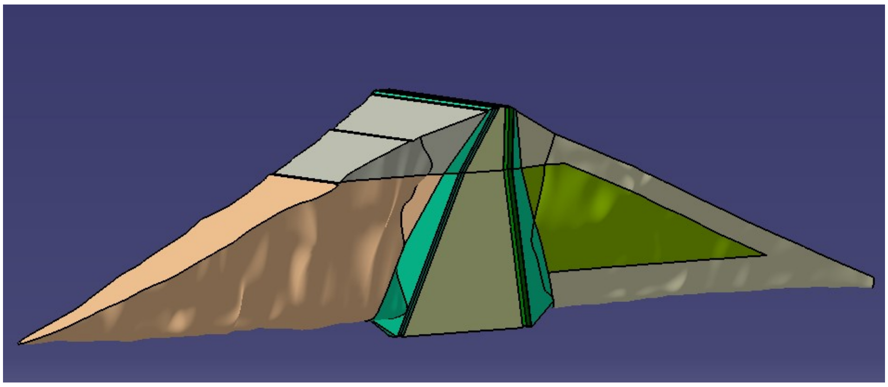

Fig. 4 Modeling of dam excavation surface

3. Parameterizing

Driving the model by the design parameters is an important function of the CATIA software [8], but it becomes a problem on how to organize such plenty parameters. The CATIA parameter design table function is a good solution. The specific method is to export all (or part) of the defined design parameters to the design table and save it as an Excel document which is related to the model. Each row (column) defines a set of possible parameter configurations, and the model can be updated to a new scheme by switching rows (columns).

Controlling and managing parameters of the model through Excel spreadsheet make it possible for model reusing and multi-program comparison, mainly reflected in: (1) parameter modification can be carried out in batches. Adding one row or column means a new scheme; (2) Model parameters controlled by Excel table can store multiple design schemes at the same time, and can be directly switched between different design schemes.

4. Secondary Development of Quantity Calculation Software

To estimate the central core dam investment, The measurement of quantities would be done properly, including the amount of excavation, the amount of embankment, the amount of dam foundation enforcement and the amount of slope enforcement. These measurements can be classified into two categories, one is about the volume measurement, and the other is about area measurements. Consider the number of items to be measured, this paper presents a new method to perform batch measurement. The specific method is as follows: define a new parameter, the type could be length or area or volume, the content could be measurement of the length or area or volume. When the model is modified or updated, the new measurement would be reflected on the parameters instantaneously. The next problem is how to get this “parameters” instantly.

VB.net is a secondary development of CATIA in the Visual Studio environment using the Visual Basic programming language. This method introduces the object-oriented programming principle, while taking into account the VB's easy-to-use features, with high development efficiency and can satisfy most of the CATIA secondary development needs. Using the VB command, the "parameter" can be read out into an Excel spreadsheet, which is the raw data for calculating the engineering quantity. Based on this, the general excel standardization template is compiled to realize the real-time output of the engineering scale. The main commands are as follows:

```
Private Sub CommandButton1_Click ()
Set Dam = CATIA. Active Document. Part.
    Dim ExcelSheet As Object
    Set ExcelSheet = CreateObject ("Excel. Sheet")
    ExcelSheet. Application. Visible = True
    ExcelSheet. Application. Cells (3, 4). Value = "CENTRAL CORE"
    ExcelSheet. Application. Cells (3, 5). Value = Dam. Parameters. Item("CENTRAL CORE"). Value
    ……
    ExcelSheet. Application. Cells (27, 4). Value = " Slope area "
    ExcelSheet. Application. Cells (27, 5). Value = Dam.Parameters. Item ("Slope area "). Value
    ……
    ExcelSheet. Save As "D:\catia_xqb\output.xls"
    'ExcelSheet. SaveAs Excel Sheet. Application.Path & "\ output.xls"
End Sub
```

Create the above VB command stream as a button in the CATIA Menu Bar. After clicking, pop up a new window, click on the button, the amount of embankment and inforcement area data are all exported to the Excel spreadsheet, and the engineering quanlity table can be obtained through the associated formula, and all the results will be shown in the final excel sheet.

5. Design optimizing

The central core dam model provided in this paper can be applied to the comparison of dam site selection, normal water storage level comparison, and dam structure optimization. The operation method is as follows: open the associated Excel parameter table, copy a new parameter, modify the relevant parameters, switch to the new parameter column, the model can be automatically updated, click the engineering quantity statistics button to generate a new model of the engineering quantity list and The calculation draft provides the basis for the decision of the engineering plan. The application process is shown in Figure 5. When applied to similar projects, just replace the topographic geological surface in the model, and then add a new parameter column in the Excel table and switch is OK.

Fig. 5 Application process

6. Conclusion

The BIM design method based on CATIA is intuitive and easy to understand. The design process is all parameterized and driven by the design table. The engineering quantity of different schemes can be output instantly by modifying the parameter-driven model update in the Excel spreadsheet. Lists and calculations. It is easy to operate, saves time, reduces the chance of human error, and can quickly adapted into other similar projects, with high quality and efficiency. At the same time, the BIM solution proposed in this paper can be applied to other complex structures that are easy to parameterize and has great reference value.

References

[1] Sheng-Hong Chen. Hydraulic Structures, Springer, 2015.
[2] Rong Zhang, Jun-Jie Wan, Liu-Hua Ji.The design of Gavity Dam based on CATIA. Yangtze River. 2014 (S1).
[3] F Wang. Parametric Modeling of Arch Dam Based on Excel-VBA and CATIA. Water Power Vol. 43. 2017 (02), in Chinese.
[4] WAN Yunhui, LI Xiaoshuai,WAN Qing. Three-dimensional Design of Concrete Faced Rockfill Dam with CATIA Software, PEARL RIVER.2015 (04).
[5] Zhong Denghua, Zhang Qinya, Du Rongxiang,.Tong Dawei, Shi Zhichao. Dynamic Construction Simulation of Core Rock-Fill Dam Based on CATIA Platform. Journal of Tianjin University (Science and Technology). Vol.48 No.12. Dec. 2015, in Chinese.
[6] Denghua Zhong, Zhichao SHI, Rongxiang Du, Shengli ZHANG. CATIA-based 3-D visualization interactive system for rock-fill dam with core-wall, Water Resources and Hydropower Engineering Vol. 46 No. 6.Jun.2015, in Chinese.
[7] Xi-Long Li, Cheng-Jia Peng, Shu-Yuan Zeng. Application of Catia in Computation of Rock Slope Stability, Water Power Vol.34. No.7.
[8] WANG Xiaoping, WANG Lu, LIN Zhigang. CATIA design table based associated design of hydraulic structure, Water Resources and Hydropower Engineering Vol. 44 No. 1.